Swiss cross drawn with 20 Br ions on NaCl(001) at room temperature

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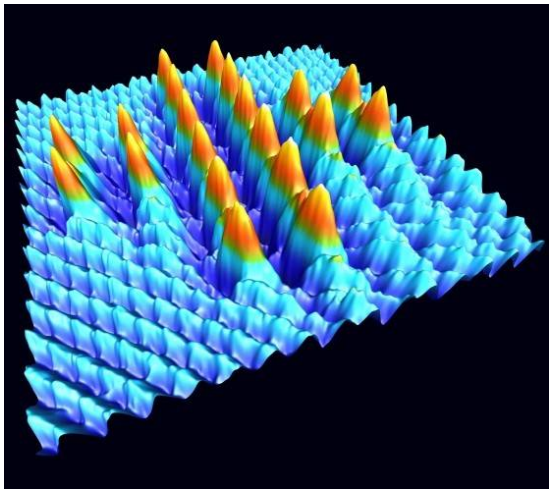
Scanning probe microscopy is intrinsically monopolistic technology to fabricate complex artificial structures on surfaces at the atomic-scale. Since the first demonstration with Xe on Ni(110) at low temperature,[1] a numerous number of such atom and molecule manipulations has been reported mainly with scanning tunneling microscopy at low temperature. Recently, atom manipulations on semiconductor surfaces with dynamic mode atomic force microscopy (DFM) at room temperature were reported.[2,3] The demonstration is definitely the milestone in the field because DFM has no restriction of the sample conductivity and indicates the possibility to fabricate an artificial structure on insulator surfaces.

Here, we report the manipulation on NaCl(001) at room temperature. Bromine ions in the NaCl surface (bulk concentration: ~0.01 Mol%) were clearly observed at the position of Cl by bimodal DFM.[4,5] A high-repeatable lateral manipulation of Br ions was performed by exchanging Br and Cl ions at a closer tip-sample distance. Basically, this lateral manipulation can be used for fabricating an artificial structure, but is rather time-consuming. Therefore, we picked up the Br ion to the tip from the sample by exchanging Cl ion of the tip, by setting a further closed tip-sample distance while the distance feedback deactivating. This vertical manipulation of picking up and depositing was highly repeatable. Over successive 40 steps of the vertical manipulation for replacing Cl to Br ions on the NaCl(001) surface, we drew the "Swiss Cross". The diffusion barrier of Br ions is high enough that the drawn cross stayed over hours at room temperature.



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